

An Approach for the Development of Requirements-Oriented Simulation Management

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1 Introduction

Dispersed and non-standardized product development and simulation data within engineering companies leads to missing notifications of changes, which are one of the main reasons for avoidable iterations in product development processes. To evade redundant iterations that diminish efficiency and to include already generated knowledge into simulation processes within virtual product development, a clear simulation management is required. It is crucial to identify the appropriate requirements accurately at the very beginning of the development process and to structure them to avoid misunderstandings between designers and simulations experts.

In this work, the authors worked closely with several academic institutions as well as with the industry partner iwis motorsysteme GmbH & Co. KG to identify the critical fields for improvement. Together with the industry partner the exchange of internal simulation requirements was examined and improvements were suggested by developing a requirements-oriented simulation management concept. A visual data management tool was used to depict the identified potential for optimization leading to a central and department crossing data storage system with defined user roles and access rights. Furthermore, a template for simulation requirements based on identified relevant knowledge was designed. This template helps to formalize the language and form of requirements. Thus, a common understanding of simulation processes including quality criteria and semantic and syntactic rules is created. The resulting simulation assignment leads to an efficiency increase in comparison to the currently used templates and includes both, the requirements template as well as further surrounding information necessary for processing simulations. As a result, knowledge can be transferred from the simulation department back to the construction department e.g. via crosschecking internal requirements in simulation assessments with a requirement database.

2 Methodology

The objectives of the work are formulated as follows:

1. Identification of the critical fields for improvement in the Product Development Process
2. Development of a requirements-oriented simulation management approach
3. Concept integration in the PDP of the industry partner and evaluation (outlook)

2.1 *Identification of critical fields for improvement with the industry partner*

The authors conducted several surveys with the employees of the industry partner, especially in the design and simulation departments, to understand the current situation regarding the product development process in the company. The surveys were in the form of personal interviews with structured questionnaires offering the employees to objectively describe the PDP situation with respect to their department. Additionally, it also gave them an opportunity to answer in subjective terms regarding the problems faced by their department with respect to knowledge management and the management of simulation requirements.

The first major problem that could be identified from the interviews and questionnaires was the lack of a standardized product development process, especially regarding the handling of simulation requirements. The lack of clear definitions for simulation standards leads to a poor understanding of simulation requirements and also a failure to keep all the departments updated on the current status of the development process. Different departments work with different versions of the design and are not aware of these non-uniformities due to the lack of a structured and standardized central.

The second problem that could be identified by following the document flow in the organization was the absence of a central documentation system process (cf. Figure 2.1). This is seen to lead to poor exchange of the latest information and an improper definition of user roles and access rights. Defining clear responsibilities for personnel with respect to updating the system can help mitigate this problem. This is taken into account in the development of the simulation management approach and will be discussed in Section 3.

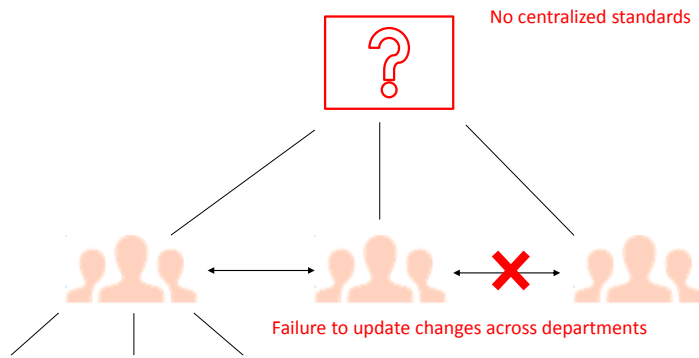


Figure 2.1 Lack of a centralized documentation system leading to unrecognized changes

2.2 Cooperation with partners from academia

The current work is conducted in cooperation with several university and industry partners within the framework of a research consortium. This collaboration facilitates the development of knowledge and competences in universities to increase the efficiency of product and process development using data provided by the industry partners. In the context of this work, Figure 2.2 depicts the particular competences exchanged in the process of creating a requirements-oriented simulation management framework.

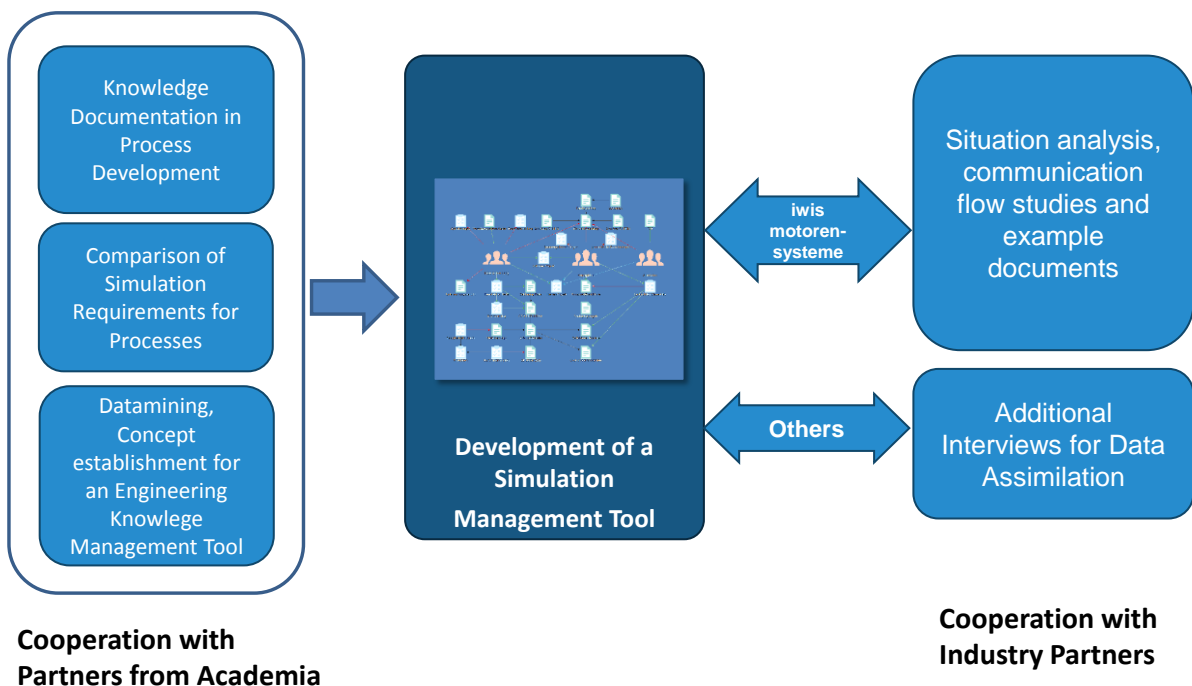


Figure 2.2 Scope of collaboration with academic (*left*) and industry (*right*) partners

3 Results and Conclusions

Understanding of the simulation requirements is the key to reducing the costs associated with delays and redundant iterations in the simulation phase. The interviews with simulation engineers and design engineers yielded an understanding that the template on which a simulation assignment is based needs to be changed. The simulation assignment is the document that specifies the type of simulation required, the results expected and other remarks by the designer (cf. Figure 3.1).

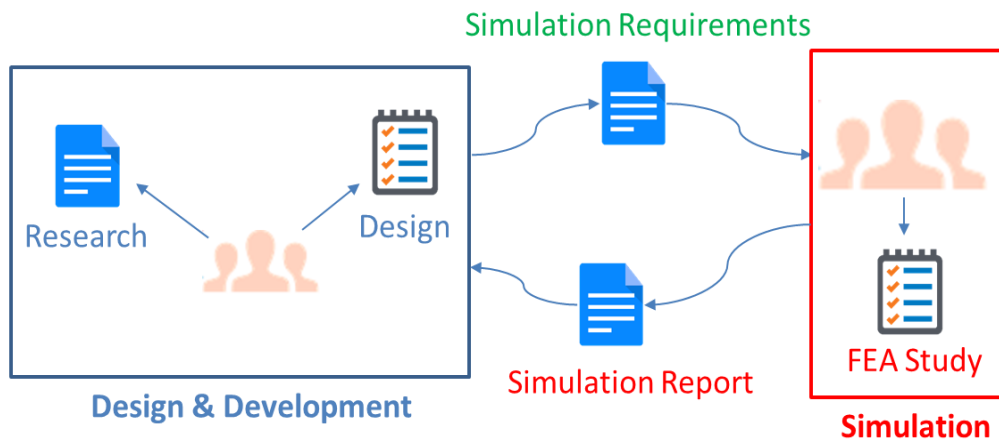


Figure 3.1 Exchange of simulation requirements and simulations reports between departments

This is the document that the simulation engineers work with and it needs to have explicit statements regarding the nature of the request. Interviews with employees and an examination of the existing templates showed that the document is currently highly subjective and leads to a poor understanding of the actual requirements. Therefore, the simulation template needs to be redefined and restructured to elicit the simulation requirements clearly. It should also give the simulation engineer multiple options in terms of material-cost tradeoff, component criticality etc. so that redundant iterations and delays are avoided. This also standardizes the template so that the same format can be used for multiple engineering components and multiple industries. Semantic and syntactic rules in a requirements template are laid out to eliminate any confusion that may arise due to misunderstanding of the linguistic structure of the template. Options to specify component quality criteria were included so that the simulation engineer has an understanding of the bounds that are allowable in the context of the simulation for the given component.

The approach developed in this paper is based on Rupp's template for requirements management in product development [1] and is modified to improve specifically the efficiency of the simulation process in industry. The new template to manage the simulation requirements is illustrated below (Figure 3.2).

The requirements template illustrated in the white text boxes in Figure 3.2 helps identify the most critical requirements in a sequential order that the design department can follow when describing the simulation task needed for a specific component. An example would help explain the content of the template more clearly. Let us assume that the design department of an automotive company 'X' wants finite element analyses performed on a particular motor of the engine assembly. The designer in charge of preparing the simulation order has to first request a particular type of simulation. Then, the component criticality is specified which states how strictly the requirements are to be adhered to by the simulation engineer. This leads to a description of the functionality of the component to give a better understanding of the component under simulation. This leads to the creation of a specific simulation object with well-defined boundary conditions. The capability of the simulation to perform analyses on the simulation object is assessed and if necessary iterations are made at this stage to make further modifications to the requirements. Once, all the specifications are fixed, the exact goals of the simulations are elicited, e.g. stresses, deflections etc. This process helps to eliminate redundant iterations or delays by helping the designer understand the simulation process. This understanding then leads to clarity in specifying the requirements. This will help the simulation engineer understand the designer's perspective and goals leading to fewer errors during the simulation process due to misunderstanding the requirements. The designer can rely upon the central database, which is a repository of knowledge based on prior simulations performed for other components in the company. Although the parts to be simulated or the simulation objects may vary during the development process, the database helps to provide an overview of the possibilities and capabilities of the simulation department. It also reduces errors by providing a knowledge bank of previous errors that may have occurred during other development processes.

The new simulation-oriented requirements management template was thus developed based on Rupp's requirements management approach. The template leads to decrease in delays during the product development processes by avoiding redundant iterations and errors. It achieves this by helping the designer to state the simulation requirements clearly and objectively, providing a central

database containing knowledge about the capabilities of the simulation department based on previous development processes and finally by facilitating a standardized simulation-oriented product development process.

The cooperation with industry partners where the template is implemented gave new perspectives, which increase the understanding of the interaction between different engineering departments. The communication systems, especially the document flow was visualized which helped identify the critical problem areas in the development process. Additional steps for improvement such as the sharing of best practices and maintaining a central documentation system were identified. In conclusion, the implementation of a standardized, comprehensive requirements-oriented simulation management process is achieved and immediate results already show considerable improvement in the product development process in the industry partners.

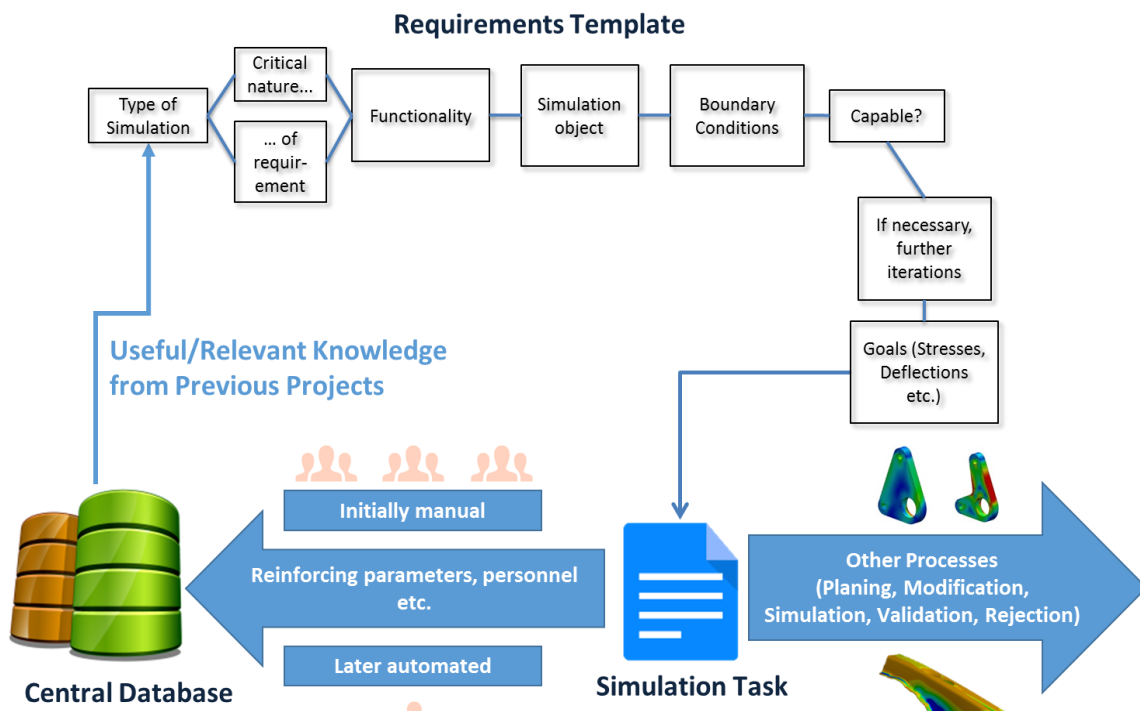


Fig. 3.2 Simulation-oriented requirements management template

4 Outlook

The authors have performed this work in cooperation, as frequently mentioned, with several industry and university partners within the framework of a research consortium. The research within this framework is ongoing and is in the latter stages of the first half of the total timeline. Therefore, the research of the authors and the partners is also current and the results in the long term of the implementation of this approach remain to be seen. While in the short term, the results are quite promising, there was no such process already existing within the organization of the industry partners. Therefore, the future work will focus on gathering data and feedback about the performance of the new system in the end and appropriately refining the requirements management template. The documentation system is expected to be updated electronically in the future with the integration of a knowledge reuse concept in the simulation management system. A knowledge management tool is also expected to be developed to use as an interface to connect previous projects together. Further work will deal with the results of the implementation of these new management systems aimed to improve the efficiency of product and process development in the industry partners.

5 References

- [1] Rupp C.; die SOPHISTen; Requirements-Engineering und -Management. München: Hanser, 5 Aufl., 2009.